Summary of Research for Grant "Impacts of Afforestation on the Provision of Ecosystem Services to Rural Communities in India (ROSES 15)." Award #NNX17AK14G

We proposed to collect several kinds of data to analyze the impact of afforestation on rural livelihoods: spatial data on the location of tree plantations within a landscape in the Kangra district of Himachal Pradesh (the Himalayan foothills), processed remote-sensing imagery documenting land cover in the same region (primarily LANDSAT-derived), government records documenting the history of afforestation in the region, household surveys, documenting the relationship of people with plantations, and ethnographic observations, documenting the political and administrative processes that lead to plantation development. We have completed the collection of all of these data. As we have collected these data, we have also provided significant opportunities for training: we trained one postdoc, Vijay Ramprasad, and three interns who were graduate students or recent graduates in Indian institutions. We also provided extensive training to our field research team, several of whom continue to work on other grants obtained by our research team. We have one paper published, one paper accepted, another paper accepted for publication pending minor revisions, two papers under review, and several more papers in various stages of preparation, pending data analysis that was slowed by the pandemic.

The primary findings of our research so far are as follows:

1.   The importance of plantations in global climate-related policy relies on a number unexamined assumptions about the benefits of plantations for ecosystems and people. In a paper under review at *Bioscience* (Fleischman et al., in review), we critically examine these assumptions. We conclude that current plantation policies are likely to be damaging when they fail to adequately account for the relationships between people and plantations.

2.   In a paper that is in the final stages of preparation (Fleischman et al. in prep), we report on the history of afforestation in Himachal Pradesh. Afforestation has had a dramatic impact on the landscape of Himachal Pradesh. Drawing on detailed government records from 1979-2015, we show that the total area afforested is 845,188 ha. This is roughly equivalent to half of all the forested area in the state, although we do not know how many of these plantations survived. The species planted have shifted over time. The most widely planted species through this period was *Pinus roxburghii*; however, the use of this species declined rapidly in the last 20 years. This reflects changes in the politics and policy for forests in the region. While *Pinus roxburghii* is an excellent timber species, it is less valued by members of local communities because it provides poor-quality firewood, tends to produce monodominant stands that produce limited fodder and other non-timber forest products, and is associated with higher incidence of fire and damaging invasive species. In 1986, green felling of timber was banned in Himachal Pradesh, and local communities have increasing political power. As a result, there is little demand for further planting of timber species, while locals are more able to influence the species choices. Unfortunately, our historical data were not georeferenced, limiting our ability to combine this analysis with remote sensing. This data has been published: http://hdl.handle.net/11299/214088

3.   In a paper currently under review at *Global Environmental Change (*Rana, Fleischman, Ramprasad & Lee under review), we utilize a more recent set of Himachal Pradesh government data that is georeferenced to examine the locations of recent (2016-2018) plantations. While we cannot yet observe the success of these plantations, we can examine the general suitability of these sites for plantation activities. We find that a high percentage of plantation sites are inappropriate because they already have high levels of canopy cover, are in areas with high levels of land tenure conflict, and/or are in areas similar to those that have recently experienced significant deforestation, and are thus themselves at high risk for deforestation. Data for this paper are published at https://doi.org/10.13020/8x0d-gb23

4.   In another paper that is in the final stages of preparation, we report on the results of ethnographic studies of local interactions with the forest department (Fischer et al. in prep). We find that where local communities are more organized around forest issues, they are better able to resist the imposition of plantations of undesirable species (particularly *Pinus roxburghii*).

5. Afforestation impacts on rural communities in the region we studied are limited by economic conditions. Our study area has experienced rapid economic growth, largely driven by opportunities for migration and off-farm employment. Most households do not depend on natural resources for their livelihoods. This blunts the impact that any changes in the provision of ecosystem services resulting from plantations have on households.

6.   While in general, most households experience few impacts – either positive or negative – from plantations, certain kinds of households are more vulnerable to negative impacts. In a paper in press at *Ecology and Society (*Ramprasad, Joglekar, and Fleischman in press), we report on a qualitative study of the impacts of plantations studied on the lives of Gaddi pastoralists, who traditionally grazed goats and sheep, moving up and down the Himalayas with the seasons. Plantations and their associated closures are a significant impediment to traditional seasonal movement. It is one of several factors pushing Gaddis away from their traditional herding occupation and towards a more sedentary lifestyle.

7. Our close work with local informants in order to locate historical plantations led us to conduct an ethnographic study of informal forest watchers, or Rakhas, documenting their struggle to gain recognition and their precarious livelihoods. This research shows the linkages between environmental justice and political ecology scholarship by examining how marginalized actors such as Rakhas, come to be included, but without influence, in conservation and development programs, and is currently in advanced stages of preparation (Ramprasad et al. in prep).

8.   We developed and published a novel deep-learning image classification method for constructing sequential features from a single image in long short-term memory (Ma et al. 2019). However we found that running the algorithm for images the size we were trying to process was prohibitively time consuming. As a result, we have developed a markedly faster strategy that uses object-based segmentation for the purpose of imposing spatial constraints and providing computational acceleration. Experimental results showed that this algorithm dramatically lowered the computation-time cost (Ma and Filippi In press; Ma et al. In revision). In recent months we have applied this algorithm to analyze land-cover changes that occurred in plantation areas that we mapped in our study area. We are working on papers that report the findings from these analyses, and we are also using this in synthetic analyses, discussed below.

9.   Our team is currently working on analyses that pair data from field surveys of plantations and households with the outputs of our remote sensing. An initial finding is that when households report that they were involved in the decision-making process around a plantation, that plantation is more likely to include species beneficial to households (confirming what our qualitative evidence told us). We will inform the LCLUC program when papers reporting these analyses are published.

10. In 2019 we applied successfully with an Indian NGO, CEDAR, for a NASEM-PEER grant, which supports CEDAR's cooperation with our research project. This grant funds CEDAR to collect carbon storage and biodiversity data in a subsample of our study plantations. Unfortunately, fieldwork on this project has been slowed by the COVID-19 pandemic.

11. In addition to formal publication, we have presented our findings at a variety of events, notably including a number of meetings and conferences in India. Our initial plans to present findings to the Himachal Pradesh Forest Department at the conclusion of the project were delayed due to the pandemic,

however our close connections to the department (co-investigator Pushpendra Rana has returned to India from his postdoc at U of Illinois and is now serving as a Chief Conservator of Forests for Himachal Pradesh) and to local officials in our study area through our field team mean that many key figures in our study area are already aware of our findings. The PEER grant with CEDAR provides additional funding for local outreach activities which we hope to complete once travel is once more possible.

Citations:

H.W. Fischer, S.S. Ali, A. Chhatre, F. Fleischman, P. Rana, and C. Rodriguez Solorzano. Local political agency in an era of carbon governance: Achieving environment-livelihood synergies through more democratic forest and landscape interventions. In preparation

F. Fleischman, S. Basant, A. Chhatre, E.A. Coleman, H.W. Fischer, D. Gupta, B. Güneralp, P. Kashwan, D. Khatri, R. Muscarella, J. Powers, V. Ramprasad, P. Rana, C. Rodriguez Solorzano, J.W. Veldman. "Pitfalls of tree planting show why we need people-centered natural climate solutions." Under Review at Bioscience.

F. Fleischman, P. Rana, H.W. Fischer, V. Guleria, R. Rana, V. Ramprasad. "Planting and replanting: Continuity and change over 36 years of tree planting in Himachal Pradesh, India." In preparation.

A. Ma, A. M. Filippi, Z. Wang, and Z. Yin, "Hyperspectral Image Classification using Similarity Measurements-Based Deep Recurrent Neural Networks", Remote Sensing, 2019, doi:10.3390/rs11020194, https://www.mdpi.com/2072-4292/11/2/194/htm.

A. Ma, and A. M. Filippi, "Hyperspectral Image Classification via Object-Oriented Segmentation-based Sequential Feature Extraction and Recurrent Neural Network," IEEE International Geoscience and Remote Sensing Symposium, In press.

A. Ma, A. M. Filippi, Z. Wang, Z. Yin, D. Huo, X. Li, and B. Güneralp, "Fast Sequential Feature Extraction for Recurrent Neural Network-based Hyperspectral Image Classification," IEEE Transactions on Geoscience and Remote Sensing, In revision.

V. Ramprasad, A. Joglekar, F. Fleischman. "Plantations and pastoralists: afforestation activities produce vulnerability among pastoralists in the Indian Himalaya". Accepted pending minor revisions at Ecology and Society

V. Ramprasad, V. Guleria, R. Rana, P. Rana, W. DePuy, Justice for intermediaries: the Van Rakhas of Kangra, stewardship of forests and struggle for recognition. In prep.

P. Rana, F. Fleischman, V. Ramprasad, K. Lee. "Tree Planting programs take root in all the wrong places" Under review at Global Environmental Change.